With ZoomControl
hear “around the corner”

Traditional directional microphone systems are based on the assumption that the hearing system user sits directly across from, and looks at their conversational partner. This is also due to the fact that with today's two microphone technology, only a limited number of directional microphone patterns can be achieved.

With ZoomControl, Phonak presents a new, unique solution to this problem. By using a remote control and hearing instruments that communicate with each other, it is now possible to create directional characteristics never before possible. In this way, even signals not originating from the front can be emphasized. Phonak has earned the right to call itself the inventor of multi-microphone technology in hearing instruments. In the early nineties, AudioZoom with its revolutionary concept of using two microphones became a worldwide sensation. With its indisputable benefits, this technology has advanced so much in the last few years that today, even hearing instruments in the low price categories are almost universally featured with two microphones.

Why two microphones?

Along with earlier traditional microphones and their omnidirectional response pattern, directional microphones have also been available in hearing systems for a long time. Traditional directional microphones select sound from a specific direction and differ from omni directional microphones in that they have two microphone ports to receive sound. In addition, they function according to a different principle. Whereas the omnidirectional microphone is purely a pressure transducer and reacts to variations in pressure, directional microphones are pressure gradient transducers and react to the rate of pressure change mathematically seen as the first deflection of pressure change over time ($dp(t)/dt$). This has known consequences, including that high frequency transmission of directional microphones is better than low frequency transmission. This effect was incorporated intentionally in order to help improve speech understanding. Despite this, however, devices with directional microphones still had a more unnatural sound quality than those with an omnidirectional microphone. So, why do we use two microphones today and not just one (directional) microphone to focus hearing in a specific direction? It is quite simple – because two microphone technology has an advantage over single microphone technology in that directional patterns can be produced which continuously adjust to changing environments. Frequency response changes occurring at the same time can be compensated for. What remains is a system with a continuous, smooth, comfortable sound which helps to improve speech understanding in noise in a variety of situations.

Directional characteristics of a two microphone system

With two microphones, a specific direction based pattern can be produced through differential interaction; that is the rear microphone signal is phase shifted and reduced by a specific factor from the front microphone. Microphone alignment plays an important role here. Typically, hearing instrument microphones are arranged back to back. The chosen direction of sensitivity can be defined by drawing a line through both microphones. In the case of hearing instruments this is from front to back, or in other words from 0° to 180°. In this alignment it is possible to continuously move between the microphone patterns shown in figure 1.

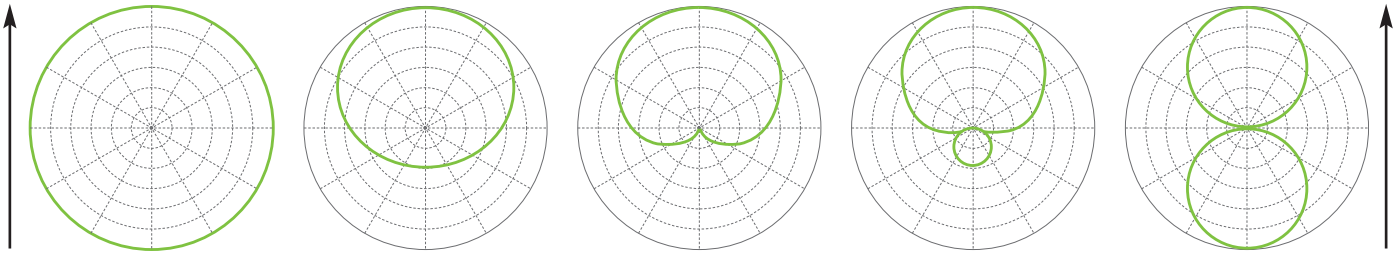

Figure 1:
Polar diagrams showing the theoretical microphone patterns which can each be continuously attained through use of two microphones. In each case, the chosen direction is towards the front (see arrow).

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In reality, the individual directional patterns are not exactly as shown because head shadow effects play an important role. In the case of a hearing aid on the right side, we see the characteristics of the front and back slopes are somewhat distorted while damping occurs on the left due to head shadow effect. (See figure 2)

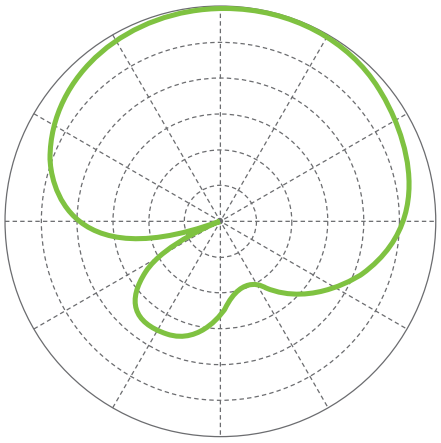

Figure 2:
Measured directional head characteristics. The distortion is due to head shadow effects.

Better understanding through improved AI-DI

How much directional patterns help to separate signal from noise can be calculated with the Directionality Index (DI) which describes the improved signal to noise ratio with the assumption that the signal occurs from the 0° and the noise is diffuse. Under these conditions, a signal to noise index of 6 dB can be achieved theoretically with the two microphone system described above. In reality, this level is achieved due to the influence of different frequency responses, as well as loudness and phase differences between the two microphones and the negative influence of the head shadow effect. One can apply the Directionality Index (DI) only to speech understanding at significant frequencies. This is possible through application of aspects of the theory of Articulation Index (AI) through which the importance of specific individual frequency bands for speech understanding is defined.

From this, the AI-DI is derived which is a measure of how much speech understanding in noise improves through use of a directional microphone system. In this case it is approximately 4 to 5 dB. In figure 3, we see how much impact a minor improvement in signal to noise ratio has on the improvement of speech understanding.

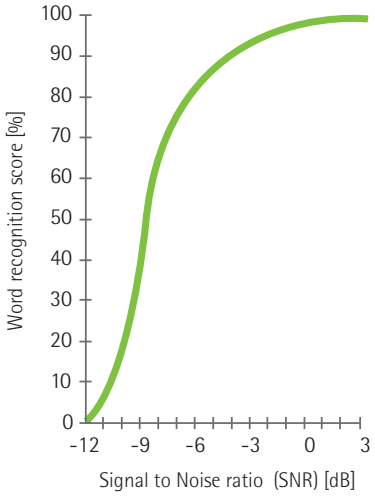

Figure 3:
Dependence of speech understanding on Signal to Noise ratio. [*H Gustav Mueller and Mead Killion: an easy method for calculating the Articulation index. Hearing Journal, Vol.3, No. 8, September 1990*]. It is clear that even small changes in the SNR have a large impact on speech understanding.

Limitations of two microphone technology

Although two microphone systems perform well in practice, there are some limits. It is only possible to produce the described directional patterns which focus to the front or to the back. A chosen direction to the right or left i.e. 90° or 270° is not possible. This specific directionality can only be achieved when both microphones are positioned side by side as shown in figure 4.

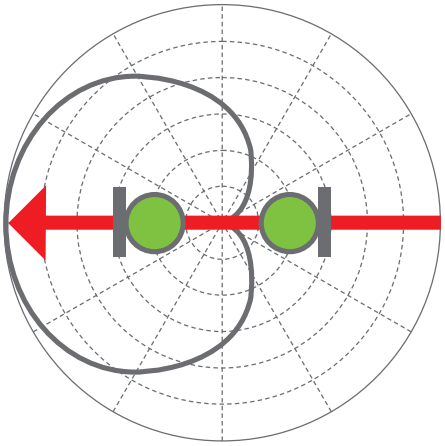

Figure 4:
Microphone patterns with directionality of 90° and 270° (arrow) is only possible when both microphones are positioned side by side.

People have two ears

This piece of wisdom provided the start to further development. It is widely accepted that a binaural fitting is the best and the most natural. The developers of hearing systems recognized quickly that modern hearing systems could now have four microphones instead of two in binaural fittings. Theoretically, they could allow the right and left microphones to be coupled. In the simplest form, one can use the front microphones of the right and left hearing instruments. In theory this allows the microphones to achieve the 90° and 270° characteristics. If we add the two back microphones we can achieve the pure right/left patterns even with head shadow effects. The many theoretical coupling possibilities are shown in figure 5.

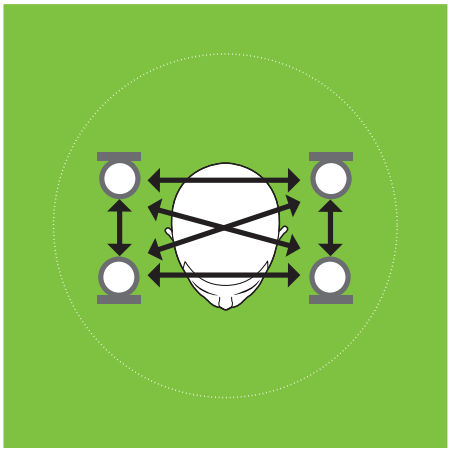

Figure 5:
All theoretically possible combinations to achieve directional microphone patterns.

The problem in technical realization

Inclusion of all four microphones in a binaural fitting with directional microphone systems requires coupling the right and left hearing instrument. This is easy to achieve through use of a cable but the market would never accept such a solution. So, the answer can only be a cableless connection. Wireless communication technology has moved more and more into the foreground in recent years. Consider the widely used WLAN (Wireless Local Area Network), through which one can, for example, have direct access to the internet or Bluetooth for connections to peripheral devices on computers or data transfer with mobile telephones. Not to forget standard FM transmitter technology which has been used for years in hearing systems. For various reasons, these processes have not been applicable to data transfer between hearing aids. Special networks called Body Area Networks (BAN) have been developed for these circumstances. These are transmission systems which characteristically transmit high volumes of data over short distances with very little power consumption.

Exélia is made for this problem

With its newest high end hearing instrument family Exélia, Phonak brings to the market a hearing system which has a BAN that makes data transfer between the right and left hearing aids possible. Through this superior technology, it has become possible to construct the best and most appropriate directional characteristics using all four microphones in a binaural fitting. This unique system called ZoomControl makes it possible for hearing impaired people using myPilot to choose specific directionalities that were previously not attainable with separately functioning hearing instruments.

Hearing “around the corner” is now possible

How does the new ZoomControl work? In normal hearing environments Exélia functions as expected for a first class automatic hearing system. The VoiceZoom system in Exélia continuously analyzes the environmental sound in 33 channels and optimizes the directional characteristics in every single channel for the best speech understanding by continually calculating the best AI-DI for every channel. Even in the automatic setting it can already identify and reduce up to 33 different sources of noise. In acoustically challenging situations, the user can now take control and activate ZoomControl through the use of a myPilot (figure 6). A previously unmanageable situation, for example, is hearing in a car. The motor running presents a noise source which fills the entire car. Until now understanding a passenger, even with the use of noise reduction and directional microphones, has still been very difficult. Now, the hearing instrument user has the possibility to focus the directional characteristics of the entire hearing system towards the passenger by simply using the appropriate button on his remote control and does not need to turn his head. Both hearing instruments switch to ZoomControl mode. If the chosen ZoomControl direction is to the right, the right hearing instrument takes on a pattern with the right sound source as its focus. This effect on its own is not enough. Therefore, at the same time, the microphone signal on the left is reduced so that little of the sound from the left is processed. In addition, the wireless connection between the instruments becomes active and sends the microphone signal wirelessly from the right side to the left side where it is received and processed. Thereby, signal processing is achieved with an exact orientation for directional hearing to the right. The action and the impact on hearing are striking. The speech signal is more clear than ever before possible with other systems. The noise remains in the background.

Figure 6:
The new myPilot remote control allows manual selection of the specific directionality of the hearing system (i.e. Exélia hearing system).

ZoomControl is the beginning of a new era in directional hearing

With Exélia and the new VoiceZoom and ZoomControl a new chapter is written in the history of multi-microphone technology. Through wireless data transfer it has become possible to achieve right and left hearing aid directionality characteristics not possible with other conventional two microphone systems. With myPilot command center, each individual can decide when the superior technology is activated and thereby can practically “hear around the corner”.